IN THE UNITED STATES DISTRICT COURT
FOR THE DISTRICT OF DELAWARE

POLAROID CORPORATION Plaintiff, v. HEWLETT-PACKARD COMPANY, Defendant.	C.A. No. 06-738 (SLR) **REDACTED – PUBLIC VERSION**

POLAROID CORP.'S RESPONSE TO HEWLETT-PACKARD CO.'S OPENING CLAIM CONSTRUCTION BRIEF

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TABLE OF CONTENTS

TABLE OF AUTHORITIES

Cases

Statutes

Other Authorities

I. INTRODUCTION

Polaroid and HP take very different approaches to claim construction in their opening briefs. Polaroid proposes claim constructions that are consistent with all of the intrinsic evidence. HP, on the other hand, makes numerous errors in its approach to claim construction. By improperly relying on extrinsic inventor testimony, ignoring the intrinsic evidence, and trying to limit the claims to the preferred embodiment, HP pushes for unsupportable constructions.

This Court should follow the repeated chorus from the Federal Circuit holding that intrinsic evidence is the "primary tool" for determining the meaning of claim terms, not HP's unreliable, extrinsic evidence. The intrinsic evidence — as shown in Polaroid's Opening Brief — is consistent with, and fully supports, Polaroid's constructions. Thus, this Court should adopt Polaroid's claim constructions.

II. HP'S APPROACH TO CLAIM CONSTRUCTION IS WRONG AS A MATTER OF LAW.

HP repeatedly makes the same two mistakes in its brief. The first is its reliance on inventor testimony. The second is its insistence on limiting the claims to the preferred embodiment.

A. Reliance on Inventor Testimony

The most obvious problem with HP's claim construction brief is its heavy reliance on extrinsic evidence, and specifically on testimony of one of the inventors, Donald Levinstone. On numerous terms, this extrinsic evidence is the only evidence HP relies upon to support its positions.

There are three reasons to ignore this extrinsic evidence. First, courts must ignore extrinsic evidence altogether unless the collected intrinsic evidence leaves the construction of a term ambiguous. *Jack Guttman, Inc. v. Kopykake Enter., Inc.*, 302 F.3d 1352, 1362 (Fed. Cir.

2002); *Bell & Howell Document Management Products Co. v. Altek Systems*, 132 F.3d 701, 706 (Fed. Cir. 1997); *Vitronics Corp. v. Conceptronic, Inc.*, 90 F.3d 1576, 1583 (Fed. Cir. 1996). Not once in the numerous times it cites inventor testimony does HP even suggest that the intrinsic evidence leaves construction of the term ambiguous. Instead, HP improperly turns straight to this extrinsic evidence without ever establishing intrinsic ambiguity.

Second, Federal Circuit precedent cautions against reliance on the specific type of extrinsic evidence on which HP relies — inventor testimony. In *Akamai Technologies, Inc. v. Cable Wireless Internet Services, Inc.*, 344 F.3d 1186, 1194 (Fed. Cir. 2003), the court explained that "what the patentee subjectively intended his claims to mean is largely irrelevant to the claim's objective meaning and scope." And, in *Bell & Howell Document Management Products*, 132 F.3d at 706 , the Federal Circuit proclaimed that inventor testimony about claim construction is "entitled to little or no consideration." Finally, in *Markman* itself, the Federal Circuit concluded that inventor testimony is "entitled to no deference." *Markman v. Westview Instruments, Inc.*, 52 F.3d 967, 985–86 (Fed. Cir. 1995) (*en banc*).

Indeed, the only case HP cites to support its use of inventor testimony, *Automotive Technologies International, Inc. v. BMW of North America, Inc.*, 501 F.3d 1274 (Fed. Cir. 2007), did not even concern claim construction. (D.I. 97, HP Op. Br. at 18, n.7) That case instead concerned a summary judgment motion on the issue of enablement. Thus, HP lacks any legal support for the primary piece of evidence on which it relies throughout its brief.

Third, the testimony HP relies upon is legally irrelevant. The purpose of claim construction is to construe the terms as one of skill in the art at the time the application was filed. *Phillips v. AWH Corp.*, 415 F.3d 1303, 1313 (Fed. Cir. 2005) (*en banc*), *cert. denied*, 546 U.S. 1170 (2006). In this case, that means one of skill in the art in 1988. But Dr. Levinstone admitted

that he had never even read the patent while he worked at Polaroid, and that his interpretations were based on his present day understanding, not what he would have understood them to mean in 1988. (Ex. A, Levinstone Dep. Tr., 136:9–14; 319:8–18). Moreover, Dr. Levinstone's [redacted]

Thus, the extrinsic inventor testimony that is the main focus of HP's brief suffers from three independent, damning legal defects. The elimination of this extrinsic evidence leaves HP with little support for its constructions.

B. Limiting Construction to the Preferred Embodiment

The other obvious problem with HP's proposed constructions is that HP improperly seeks to narrow the claims so that they are limited to luminance electronic information signals, which are used in the preferred embodiment. The Federal Circuit has repeatedly warned against confining the claims to specific embodiments of the invention described in the specification. *See, e.g.*, *Phillips*, 415 F.3d at 1323. And, in *Nazomi Communications, Inc. v. ARM Holdings, PLC*, 403 F.3d 1364 (Fed. Cir. 2005), it explicitly held that claims may embrace "different subject matter than is illustrated in the specific embodiments in the specification." *Naxomi,* 403 F.3d at 1369. In particular, the Federal Circuit has expressly rejected the contention that if a patent describes only a single embodiment, the claims of the patent must be construed as being limited to that embodiment. *See, e.g.*, *Phillips*, 415 F.3d at 1323; *Gemstar-TV Guide Int'l, Inc. v. Int'l Trade Comm'n*, 383 F.3d 1352, 1366 (Fed. Cir. 2004).

III. FLAWS IN HP'S CONSTRUCTION OF INDIVIDUAL CLAIM TERMS

A. The Preambles of Claims 1 and 7 Are Not Limitations.

In response to the only office action before issuance of the '381 patent, the inventors amended the Claim 1 and 7 preambles, adding "having a value within a determinate dynamic range of values" to provide an antecedent basis for the term "dynamic range" later in the claims:

> A [system/method] for continuously enhancing electronic image data received in a continuous stream of electronic information signals, each signal <u>having a value within a determinate dynamic range of values and</u> corresponding to one of a plurality of succeeding pixels which collectively define an image, said [system/method] comprising:

(D.I. 99, Joint Appendix ("JA") at 53, 56–57) (addition underlined). On this basis, HP argues that both "electronic information signals" and "dynamic range" are limiting in the preamble. (HP Op. Br. at 13).

The first error HP makes is to argue that "electronic information signals" is limiting in the preamble because that term was not added to provide an antecedent basis. In fact, it was never added at all, and the Examiner never suggested that the term provided an antecedent basis. (*See* J.A. at 47–50). Moreover, its presence in the preamble does not provide an antecedent basis, as the term "electronic information signals" appears in the first claim element, lacking the obligatory "the" or "said" that would signify the need of an antecedent basis. Thus, although the term needs to be construed, it is not limiting in the preamble.

The second error HP makes is to automatically conclude that "dynamic range" is limiting merely because it provides an antecedent basis, even though that is not the law. (HP. Op. Br. at 13). Although preambles may act as limitations when they provide an antecedent basis for claim terms, they will not do so when the claim elements set forth the complete invention and the preamble merely states the purpose or intended use of the invention. *Lucent Tech., Inc., v. Extreme Networks, Inc.*, 367 F. Supp. 2d 649, 667 (D. Del. 2005). In *Lucent*, this Court held that

a term was not limiting despite providing an antecedent basis because the preamble merely stated an intended use of the claimed invention. *Id.*

HP then argues more generally that numerous preamble terms — "continuously enhancing", "electronic image data received in a continuous stream of electronic information signals" and "each signal having a value within a determinate dynamic range of values" — are limiting because they purportedly breathe life and meaning into the claims. (HP Op. Br. at 13). Preambles do not "breathe life and meaning" into the claims, however, when the body of the claims set forth the complete invention, as they do here. *Innova/Pure Water, Inc. v. Safari Water Filtration Sys., Inc.*, 381 F.3d. 1111, 1118 (Fed. Cir. 2004); *Altiris, Inc. v. Symantec Corp.*, 318 F.3d 1363, 1371 (Fed. Cir. 2003). These preambles merely state the purpose for the inventions and could be wholly replaced with "a system comprising:" or "a method comprising:" without affecting the claimed invention. (*See* D.I. 100, Pol. Op. Br. at 14–17).

HP's reliance on three cases, *Poly-America, L.P. v. GSE Lining Technology*, 383 F.3d 1303, 1310 (Fed. Cir. 2004), *Porter v. Farmers Supply Service, Inc.*, 790 F.2d 882 (Fed. Cir. 1986) and *Biacore v. Thermo Bioanalysis Corp.*, 79 F. Supp. 2d 422 (D. Del. 1999) is misplaced. (HP Op. Br. at 13–15). In *Poly-America*, the court only found the preamble limiting because of excessive repetition and statements about the importance of that preamble throughout the specification, combined with the complete restatement of that preamble in every one of the seven claims, which is not true for the '381 patent. *Porter* does not even address construction of preambles. And, *Biacore* only construed a portion of the preamble concerning the field of use of an invention because the claims could not be divorced from that intended field of use, which HP does not assert for the '381 patent. *Biacore*, 79 F. Supp. 2d at 457.

B. Claim 1

1. Terms in the Preamble

Even if the Court treats the preamble terms as limitations, it should reject HP's proposed constructions. HP seeks to improperly limit the terms to the preferred embodiment, often based solely upon inventor testimony.

a. "electronic information signals"

HP argues that "electronic information signals" should be limited to luminance signals because that is "the only disclosed usage." (HP Op. Br. at 16). This ignores the claim language itself, which lacks the word "luminance." HP also ignores the disclosure in the specification that teaches that electronic information signals can be color, luminance, or chrominance values. (Ex. 1 to D.I. 100, '381 Pat., 3:33–34, 38–43).

Even the portions of the specification that HP quotes on page 17 of its brief support Polaroid's construction. For example, the first excerpt HP quotes recognizes that luminance is merely the preferred embodiment: "[t]he electronic information signal values . . . are ***preferably*** converted to luminance . . . ." (*See id.* at 17 (citing'381 Pat., 3:35–43)) (emphasis added). The other two excerpts HP quotes on page 17 both refer to "***luminance*** electronic information signals." If one of skill would have understood "luminance" to be inherent in "electronic information signal," there would have been no need for the inventors to specify as they did.

HP's reliance on *LizardTech, Inc. v. Earth Resource Mapping, Inc.*, 424 F.3d 1336 (Fed. Cir. 2005), a case where the court rejected a construction that would not have been enabled by the specification, is unavailing because Polaroid's construction is enabled and described. (HP Op. Br. at 18). The specification discusses different types of electronic information signals and algorithms for modifying those information signals. Although the preferred embodiment used

luminance values, nothing in the specification would suggest that color values may not also be used. ('381 Pat., 3:25–34).

HP finally argues that there is a "well known convention" of using "Y" to denote a luminance signal. (HP Op. Br. at 17). But the first time that the inventors introduced "Y" in the specification, they used Y to refer to electronic information signals generally, without limiting it to luminance signals: "electronic information signals . . . are received at terminal Y_{input}." ('381 Pat., 3:3–6). Left with nothing else, and without establishing ambiguity in the intrinsic evidence, HP then turns to inventor testimony, which is both legally improper and itself ambiguous.[1] (*See* HP Op. Br. at 18). Therefore, the Court should reject HP's proffered construction and adopt Polaroid's construction.

b. "electronic image data received in a continuous stream of electronic information signals"

HP's construction of this phrase as "an uninterrupted stream of received luminance image data [pixels] defining an original image to be recorded" suffers from three problems. One is that it requires that the stream be uninterrupted, which lacks any intrinsic support. Indeed, HP does not even try to marshal a basis in the intrinsic evidence. (HP Op. Br. at 19). To the contrary, the claim language and the specification merely teach that the signals be in a successive series by equating "continuous stream" with a "successive series." ('381 Pat., 1:68–2:1, 8:5, 9:55; Pol. Op. Br. at 21). Moreover, each electronic information signal for a pixel is separate and distinct, just as the pixels are. ('381 Pat., Abstract, 1:11–13, 1:68–2:1). These individual signals,

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1 Just prior to the testimony cited by HP, Dr. Levinstone testified [redacted]

therefore, are transmitted successively, and there is necessarily an "interruption" between each signal because each one is separate from the others.

The fact that HP does not discuss the intrinsic evidence for this term obviously prevents HP from establishing any ambiguity in that intrinsic evidence and, therefore, from relying on extrinsic evidence — a single dictionary — for support. (HP Op. Br. at 19). *See Guttman*, 302 F.3d at 1362 (holding a claim construction at odds with an unambiguous definition in the intrinsic evidence constitutes an abuse of discretion). And that dictionary definition is inconsistent with the intrinsic evidence, as already explained.

In addition, HP's construction of "continuous stream" is inconsistent with its own construction of "continuously," as "successively." (HP Op. Br. at 14). Thus, HP's construction runs afoul of the canon that like terms should be construed consistently. *Rexnord Corp. v. Laitram Corp.*, 274 F.3d. 1336, 1342 (Fed. Cir. 2001); *see also Southwall Tech. Inc. v. Cardinal IG Co.*, 54 F.3d 1570, 1579 (Fed. Cir. 1995) (holding that "[t]he fact that we must look to other claims using the same term when interpreting a term in an asserted claim mandates that the term be interpreted consistently in all claims").

The second problem with HP's construction is its limitation to "luminance" signals, which would restrict the claim to the preferred embodiment. That is wrong under the law. *See Phillips*, 415 F.3d at 1323 (warning against confining the claims to the specific embodiments of the invention). And, Polaroid has repeatedly demonstrated that the specification describes multiple types of electronic information signals, including color and chrominance as well as luminance. (Pol. Op. Br. at 18–19).

The third problem is that HP's construction requires that the signals define the image "to be recorded," in an attempt to limit the scope of the claim to image-recording devices, like

cameras. (HP Op. Br. at 20–21). But nothing in the language of this or any claim even suggests such a narrow scope. To the contrary, the specification repeatedly discusses using the invention on previously-recorded, or stored images:

- The abstract refers to modifying "the electronic information signal corresponding to each pixel ***of the image recorded***." ('381 Pat., Abstract) (emphasis added).

- The invention "enhance[s] electronic image data received in a continuous stream of electronic information signals, each signal of which correspond to one of the plurality of succeeding pixels which collectively define ***the recorded image***." (*Id.*, 2:63–68) (emphasis added).

- Referring to signals entering the system, the specification explains that "electronic information signals each corresponding to one of a plurality of pixels from ***the recorded image*** are received at terminal Y_{input}." (*Id.*, 3:3–6) (emphasis added).

HP also does not suggest any ambiguity in the intrinsic evidence as to whether the claims rèquire a recording device before turning to extrinsic inventor testimony. (HP Op. Br. at 20). Even if considering this testimony were appropriate, Dr. Levinstone's testimony, while ambiguous, seems to contradict HP's construction. In the portion HP quotes, Dr. Levinstone states [redacted] (*Id.*)

The claim language and specification, therefore, demonstrate the problem with limiting the scope of the claim to an image-recording device. And HP fails to present anything beyond ambiguous, contradictory extrinsic evidence to the contrary.

Leaving aside the three problems with HP's construction, its attack on Polaroid's construction is specious. HP contends that Polaroid's construction is so broad as to allow data from something other than an image. (HP Op. Br. at 21). But Polaroid's construction explicitly states that the signals provide "pixel" information. (Pol. Op. Br. at 19). The specification makes clear that pixels define an image. (*See* '381 Pat., 2:67–68). Indeed, even HP's brief defines

"pixels" as "picture elements." (HP Op. Br. at 2). Obviously, these signals relate to images. Therefore, the Court should reject HP's proffered construction and adopt Polaroid's construction.

c. "each signal having a value within a determinate dynamic range of values"

HP makes the same mistake in construing this phrase as it does elsewhere — attempting to limit it to luminance values of the preferred embodiment: "each received pixel has an associated luminance value that lies within a predetermined group of luminance values." (HP Op. Br. at 21). This construction is wrong for the same reasons as the other constructions that HP advances with the same limitation.

HP's criticism of Polaroid's proposed construction is misplaced. HP argues that Polaroid's construction — "each signal being associated with a value that lies within a range of possible values bounded by definite limits" — would encompass non-integer values, which would be impossible for digital signals. For example, as HP noted, an 8-bit system may only encompass integers from 0 to 255, and it would be impossible to generate non-integers in such a system: "it is impossible to represent 250.5 in an 8-bit system." (HP Op. Br. at 23). But that is precisely why Polaroid's construction limits the values to "a range of *possible* values" thereby avoiding the problem that HP raises.

It actually is HP's construction that suffers this defect. HP merely proposes that the values fall within a "predetermined group," a term that would allow for non-integers, and would be problematic for the reasons HP itself states. Therefore, the Court should reject HP's proffered construction and adopt Polaroid's construction.

2. Claim 1's First Element: "Means for Averaging . . ."

a. Function

Although HP asks the Court to construe a function different from that specified in the claim, HP's own brief seems to agree that the function is what the claim recites:

> The function is precisely stated: "averaging electronic information signals corresponding to selected pluralities of pixels and providing an average electronic information signal for each said plurality of pixels so averaged."

(HP Op. Br. at 25). That language matches the claim, and Polaroid's construction, exactly. It is unclear why HP proposes a different construction to the Court, given the law that the function of such a claim is the language that follows "means for." *Lockheed Martin Corp. v. Space Sys./Loral, Inc.*, 324 F.3d 1308, 1319 (Fed. Cir. 2003).

b. Construction of "averaging" within the stated function

In seeking to limit "average" to an "arithmetic mean," HP ignores the intrinsic evidence and goes straight to a single piece of extrinsic evidence (an algebra textbook),[2] as it does throughout its brief. (HP Op. Br. at 24). As already discussed, failure to first establish ambiguity in the intrinsic evidence precludes consideration of extrinsic evidence. *Guttman*, 302 F.3d at 1362.

Moreover, the intrinsic evidence contradicts HP's construction. The term "arithmetic mean" could have been used in the claim, but was not. And, the plain meaning of "average," which can include weighted averages, is broader than HP's proposed construction. Indeed, the specification provides examples of two methods for computing the average: a low pass filter and a block average. ('381 Pat., 3:61–68). As Polaroid's opening brief explained, low pass filters

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2 The contemporary dictionary Polaroid referenced in its opening brief, which is consistent with the specification, contradicts the extrinsic evidence HP relies upon. (Pol. Op. Br. at 21).

compute averages other than arithmetic means. (Pol. Op. Br. at 21; Ex. 2 to D.I. 100, Wayne Niblack, AN INTRODUCTION TO DIGITAL IMAGE PROCESSING 77–81 (Prentice-Hall International (UK) Ltd. 1986)). Because "a patentee is entitled to a definition that encompasses all consistent meanings" of the term, the term "averaging" should not be read as narrowly as HP contends. *TI Group Auto. Sys. (N. Am.), Inc., v. VDO N. Am., L.L.C.*, 375 F.3d 1126, 1136 (Fed. Cir. 2004).

c. **Structure**

The fact that the limitations that HP seeks to impose on this claim element are improper is apparent from even a cursory glance at the specification's description of the structure for averaging:

<u>'381 Patent Specification</u>	**<u>HP Construction</u>**
The averager 12 may comprise a low pass filter as is well known in the art which operates to provide an average value electronic information signal A_v corresponding to the average luminance values for a selected window or plurality of pixels that continuously changes in correspondence with each succeeding pixel value to be enhanced. Alternatively, the averager may comprise a block average in which a selected group or block of pixel values is averaged to provide one average value electronic information signal A_v in correspondence with each pixel value of that group to be enhanced. ('381 Pat., 3:61–4:4).	a block averager 12 with a buffer memory that takes luminance as an input and outputs an average luminance value that is correlated to each pixel in the block, and equivalents thereof. (HP Op. Br. at 25).

The most obvious problem with HP's construction is that it excludes a low pass filter as an acceptable structure for the averager. HP attempts to defend this exclusion based on a convoluted reading of the claim language that would require each pixel be contained in only one block of pixels to be averaged. (HP Op. Br. at 26). The claims, however, do not require such a limitation.

The first element of Claim 1 sets forth what the averager actually does: it "averag[es] electronic information signals corresponding to select pluralities of pixels and provid[es] an average electronic information signal for each said plurality of pixels so averaged." ('381 Pat., 8:1–2). Nothing in the claim language limits how many pluralities must be averaged, or whether a pixel may be used in more than one average. By HP's own admission, both a block averager and a low pass filter accomplish this function. (HP Op. Br. at 6–7).

HP bases its argument on the second element of the claim, which describes using that calculated average for the "select plurality of pixels" to select a transfer function, rather than on the function of the averager itself: "each transfer function is selected as a function of the electronic information signal for one pixel and the average electronic information signal for the select plurality of pixels containing said one pixel...." HP contends that because the word "the" precedes "select plurality of pixels containing said one pixel," every individual pixel value may only be found in a single averaged plurality. (HP Op. Br. at 26).

HP's strained construction is wrong, as the case law demonstrates. When the article "the" precedes a term also found earlier in a patent claim, courts construe the second instance of that term to be referring back to the earlier term, treating "the" akin to "said." In *NTP, Inc. v. Research In Motion, Ltd.*, 418 F.3d 1282, 1306 (Fed. Cir. 2005), *cert. denied*, 546 U.S. 1157 (2006), a case that HP cites, the court held that the definite article "the" found in "the at least one of the plurality of destination processors," referred to the antecedent "at least one of a plurality of destination processors in the electronic mail system." (HP Op. Br. at 33). Similarly, the court in *Boehringer Ingelheim Vetmedica, Inc. v. Schering-Plough Corp.*, 320 F.3d 1339, 1344–45 (Fed. Cir. 2003) held that "the virus" referred back to the "swine infertility and respiratory syndrome virus" earlier in the claim. And, in *Inline Connection Corp. v. AOL Time Warner Inc.*, No.

CIVA 02-272 MPT, CIVA 02-477 MPT, 2007 WL 275929, *4 (D. Del. Jan. 29, 2007), this Court found "the telephone wiring network" referred back to "a telephone wiring network."

A straightforward reading of Claim 1 is consistent with the case law, demonstrating that "the select plurality of pixels" in the second element merely refers back to the "plurality of pixels so averaged" in the first element. HP's strained construction, on the other hand, purports to exclude structure clearly associated with the function in the specification. ('381 Pat., 3:61–67).

The second major problem with HP's construction is that it includes buffer memory as part of the structure, even though buffer memory does not actually do the averaging. (HP Op. Br. at 26). The corresponding structure in a means-plus-function claim must actually perform the recited function, not merely enable the pertinent structure to operate as intended. *Asyst Techs., Inc. v. Empak, Inc.*, 268 F.3d 1364, 1370–71 (Fed. Cir. 2001). In *Asyst*, the Federal Circuit held that a "communication line" was not part of the claimed structure, even though the specification stated that the line was necessary to allow the structure to accomplish the function. *Id.* The court reached that conclusion because the communication line did not actually perform the recited functions. *Id.* Similarly, although the '381 specification indicates that buffer memory is needed to assist the averager, the buffer memory itself does not calculate the average. ('381 Pat., 4:8–9). Buffer memory, therefore, is not part of the necessary structure.

The third major problem is HP's continued effort to limit the claim to luminance electronic information signals, which again HP bases solely on extrinsic inventor testimony. (HP Op. Br. at 27). That testimony should be disregarded for the reasons already discussed. Moreover, the testimony itself demonstrates the inventor's uncertainty in this regard. Dr. Levinstone [redacted]

[redacted] The specification directly contradicts Dr. Levinstone's speculation; instead, the more general "electronic information signal" is consistently used in every part of the specification except for the Description of the Preferred Embodiment, where "luminance electronic information signal" is used. (*See* Pol. Op. Br. at 15). Therefore, the Court should reject HP's proffered construction and adopt Polaroid's construction.

3. Claim 1's Second Element: "Means for Selecting . . . and for Subsequently Transforming . . ."

a. Function

HP also fails to track the claim language following "means for" with respect to this second element, and its construction of the function is therefore wrong. (HP Op. Br. at 34–35).

b. Construction of "dynamic range of the electronic information signals" within the stated function

The claim language uses this term in describing a ratio: "the ratio of the value of the average electronic information signal to the dynamic range of the electronic information signals." The only ratio described in the specification is A_v/M, where M "may be selected to be any value within the dynamic range." ('381 Pat., 4:39–41). In the example discussed in the preferred embodiment portion of the specification, M was chosen to be 128. (*Id.*, 4:36–39).

HP's proposed construction — that the denominator in this ratio should be the maximum number of possible values —not only would exclude the preferred embodiment, but it would not even be possible given the description in the specification. (HP Op. Br. at 37). "[I]t is . . . well established that a claim construction that excludes a preferred embodiment is "*rarely, if ever, correct.*" *Dow Chem. Co. v. Sumitomo Chem. Co.*, 257 F.3d 1364, 1378 (Fed. Cir. 2001) (citing *Vitronics*, 90 F.3d at 1583) (emphasis in original). And, constructions without support in the specification are to be avoided. *Saunders Group, Inc. v. Comfortrac, Inc.*, 492 F.3d 1326, 1333

(Fed. Cir. 2007). Here, HP's construction would require M to be 256 for an 8-bit system, which is the system described in the specification. That would preclude the preferred embodiment, 128, and so HP's construction should be rejected for that reason alone. But more obviously, the 256 that HP proposes is not "within the dynamic range" of an 8-bit system, whose maximum value can only reach 255, as illustrated in Figure 2 of the patent. ('381 Pat., Fig. 2, 3:46–49; 4:66–68). Thus, it would not be possible for any signal value to reach 256 as HP proposes.

It is true that "dynamic range of the electronic information signals" in Claim 1 is slightly different from "select proportionate value of the dynamic range of the electronic information signals" in Claim 7. Similar language in different claims can cover identical subject matter, especially when there is support in the specification. *Anderson Corp. v. Fiber Composites, LLC*, 474 F.3d 1361, 1369–70 (Fed. Cir. 2007); *Advanced Cardiovascular Sys., Inc. v. Medtronic Vascular, Inc.*, 182 Fed.Appx. 994, 998–99 (Fed. Cir. 2006). As explained in Polaroid's opening brief, Claims 1 and 7 are claiming the same ratio: A_v/M. (*See* D.I. 100, Pol. Op. Br. at 26, 36). Claim 1 does so as a means-plus-function element and Claim 7 does so as a method claim. Notwithstanding the difference in scope between the two claims, it is the value M that this disputed claim language is referencing in both Claims 1 and 7. Therefore, the minor difference in terms would not prompt one of skill in the art to ignore the support in the specification for Polaroid's construction.

c. Structure

HP initially argues for indefiniteness. (HP Op. Br. at 35–36). But although the specification's disclosed algorithm, "$\gamma = (1+C)^{(Av/M - 1)}$", lacks a mathematical variable for the individual electronic information signal, one of skill in the art would understand that this algorithm determines γ "as a function of the electronic information signal for one pixel." The signal of that one pixel, after all, is what determines which average is chosen.

Both the specification and HP's own brief demonstrate that the average depends on the "signal for one pixel." The average with a low pass filter corresponds to a window of pixels that changes to correspond to each individual pixel. ('381 Pat., 3:62–67). And, which block average is used depends on the signal identifying the location of the individual pixel as well. (*Id.*, 3:67–4:4). The figures on pages 6 and 7 of HP's brief demonstrate this dependence graphically, showing how the location of the one pixel determines the average.

If there is any ambiguity in this regard, extrinsic evidence eliminates it. It was known in the art that part of the electronic signal providing information about the pixel specifies that pixel's location. (Ex. B, Azriel Rosenfeld, DIGITAL PICTURE PROCESSING 4 (2nd Ed., Vol. 2 Academic Press 1982). One of skill in the art thus would understand that selection of the transfer function is accomplished "as a function of the electronic information signal for one pixel," because the location information in that signal determines which average to use in selecting the transfer function.

HP's second indefiniteness argument, consisting of just three sentences, is that there is no disclosure of an average electronic information signal, A_v, being divided by 256, which HP contends is the proper construction of "dynamic range." HP's argument merely demonstrates that its previous argument on that term's construction could lead to invalidity, and as already noted, such constructions are to be avoided.

Ignoring its indefiniteness arguments, HP then maintains that the disclosed structure for this claim element is limited to the circuit diagram in Figure 4. (HP Op. Br. at 36). But Figure 4 is only described as one embodiment, and only discussed in the portion of the specification on the preferred embodiment. (*See* '381 Pat., 2:48–50 (describing Fig. 4 as showing "a system"); 6:43–46). Indeed, immediately after discussing Figure 4, the specification states: "Other

embodiments of the invention including additions, subtractions, deletions and other modifications of the preferred disclosed embodiments of the invention will be obvious to those skilled in the art and are within the scope of the following claims." (*Id.*, 7:55–59). Claims should not be limited in this manner. *Phillips*, 415 F.3d at 1323.

Neither of the cases HP cites supports its contention that physical circuitry is necessary. In *Medical Instrumentation & Diagnostics Corp. v. Elekta AB*, 344 F.3d 1205, 1213 (Fed. Cir. 2003), the court merely held that a figure directed to method claims could not be identified as structure for an apparatus. And *Faroudja Laboratories, Inc. v. Dwin Electronics, Inc.*, 76 F. Supp. 2d 999, 1012 (N.D. Cal. 1999), is also inapposite; it merely held that a single disclosure of a box titled "comparator" failed to provide an adequate disclosure. In contrast, the Federal Circuit has recognized that algorithms are sufficient structure for means-plus-function claims. *See Harris Corp v. Ericsson, Inc.*, 417 F.3d 1241, 1253 (Fed. Cir. 2005) ("A the computer implemented means-plus-function term is limited to the corresponding structure disclosed in the specification and equivalents thereof, and the corresponding structure is the algorithm."). Therefore, the Court should reject HP's proffered constructions and adopt Polaroid's constructions.

C. "Determined Constant" in Claims 3 and 9

Claims 3 and 9 both claim a "determined constant." Claim 3, however, is a further means-plus-function claim, which HP ignores in its brief. And, because HP did not identify the claimed function and the structure corresponding to that function, its construction cannot be correct. *See Lockheed Martin*, 324 F.3d at 1319 (providing the proper construction for means-plus-function claims).

Regardless, in construing "determined constant," HP again seeks improperly to narrow the term's scope. The plain meaning of "determined constant" is "chosen number." The term

does not suggest the purpose of the constant. But HP's construction attempts to do so, suggesting that "constant" means a "control parameter." But it is improper to limit a claim term based on the "perceived 'purpose'" of the invention. *E-Pass Tech., Inc. v. 3COM Corp.*, 343 F.3d 1364, 1370 (Fed. Cir. 2003). Therefore, the Court should reject HP's proffered constructions and adopt Polaroid's constructions.

D. Claim 7

1. HP's Attempt to Rewrite the Claim

Scattered at various points in its brief, HP presents complete re-writes for the last two elements of Claim 7. (HP Op. Br. at 28, 32). The degree of rewriting is obvious by comparing HP's construction with the actual claim language:

<u>**Claim 7**</u>	<u>**HP's proposed construction**</u>
selecting one of a plurality of different transfer functions for the electronic information signal for each of the plurality of succeeding pixels in a manner whereby each transfer function is selected as a function of the electronic information signal for one pixel and the average electronic information signal for the select plurality of pixels containing said one pixel; and	*each input pixel has an associated* transfer function *out of different* transfer functions, *and the* transfer function *is selected based on the input pixel value, and the average that was formed using the input pixel value, where each input pixel is part of only one average;* and
transforming the electronic information signal corresponding to each pixel by the transfer function selected for that pixel wherein said transfer function is selected further as a function of the ratio of the value of the average electronic information signal to a select proportionate value of the dynamic range of the electronic information signals such that the ratio increases in correspondence with the increase in the value of the average electronic information signal.	*each input pixel value that has been part of the averaging step is altered based on the corresponding average electronic information signal to which it is associated and based on the result of dividing a first existing data value representing the average electronic information signal by a second existing data value representing a select proportionate value of the dynamic range of the average electronic information signals.*

The result is rampant inconsistency: inconsistency with HP's construction of terms in other claims and inconsistency with HP's approach to construing other claims.

HP's Claim 7 constructions differ from its constructions of like terms in other claims, even though like terms are to be construed consistently throughout the claims. *Rexnord*, 274 F.3d. at 1342. For example, HP fails to apply its construction of "electronic information signal" from Claim 1 to Claim 7. In Claim 1, HP contends that "electronic information signal" means "signal providing luminance pixel information". (HP Op. Br. at 16). Yet, in Claim 7, HP contends it means "input pixel". (*Id.* at 28, 32).

More generally, HP's entire approach for Claim 7 is inconsistent with its approach for Claim 1 and with the law. The purpose of claim construction is to alleviate juror confusion to allow the jury to intelligently evaluate infringement. *Sulzer Textil A.G. v. Picanol N.V.*, 358 F.3d 1356, 1366 (Fed. Cir. 2004). The only terms that need be construed are those in controversy, and only to the extent necessary to resolve the controversy. *Vivid Techs., Inc. v. Am. Sci. & Eng'g, Inc.*, 200 F.3d 795, 803 (Fed. Cir. 1999). Even though the language in Claims 1 and 7 is almost identical, HP's approach proposes a near-complete rewrite of Claim 7 contrasting with only minor substitutions in Claim 1. HP's approach makes no sense. HP either believes the jury will be incapable of understanding any of the language found in Claim 7 (warranting its near-complete rewrite), or HP believes the jury will be able to understand most of the same terms found in Claim 1 (warranting only minimal construction). These positions are inconsistent and run afoul of the law. Consequently, the Court should reject HP's proposals for Claim 7 based on these inconsistencies.

2. HP's Specific Constructions

Absent the inconsistencies, HP's specific constructions still warrant rejection. HP's separate construction of "select proportionate value of the dynamic range of the electronic

information signals" transparently seeks to add a limitation — "selected depending on where the least enhancement is desired" — found nowhere in the claim.

And HP trots out the same argument to support its construction of Claim 7's second element (beginning "selecting…") as it used to argue that low pass filters are an unacceptable structure — that a pixel value may only be used in the calculation of a single average, not multiple ones. As already explained, however, that construction misreads the claim language and ignores the specification. Therefore, the Court should reject HP's proffered constructions and adopt Polaroid's constructions.

E. HP's Miscellaneous Indefiniteness Arguments

HP also argues that Claims 2, 3, 8 and 9 are indefinite for referring to areas of "low," and "high" light intensity levels, to individual pixels of the "lowest" and "highest" light intensity levels, and to "areas of higher contrast," because they do not provide specific numeric limitations. But HP must establish indefiniteness by clear and convincing evidence. *Intel Corp. v. VIA Techs., Inc.*, 319 F.3d 1357, 1365–66 (Fed. Cir. 2003). And a claim is only indefinite under § 112 ¶ 2 if it is "insolubly ambiguous, and no narrowing construction can properly be adopted." *Exxon Research & Eng'g Co. v. United States*, 265 F.3d 1371, 1375 (Fed. Cir. 2001).

The terms that HP complains of are relative terms. But a claim is not indefinite merely because its scope is not ascertainable from the face of the claim. *LNP Eng'g Plastics, Inc. v. Miller Waste Mills, Inc.*, 275 F.3d 1347, 1359–60 (Fed. Cir. 2001). Instead, if one of ordinary skill in the art would understand what is claimed by the relative terms in light of the specification, the claim is not indefinite. *Seattle Box Co. v. Indus. Crating & Packing, Inc.*, 731 F.2d 818, 826 (Fed. Cir. 1984) (holding claim using "substantially equal to" was not indefinite); *Rosemount, Inc. v. Beckman Instruments, Inc.*, 727 F.2d 1540, 1547 (Fed. Cir. 1984) (holding claim using "close proximity" was not indefinite).

Figure 2 and the underlying algorithms and descriptions provide the context for one of skill in the art to understand these relative terms:

FIG 2

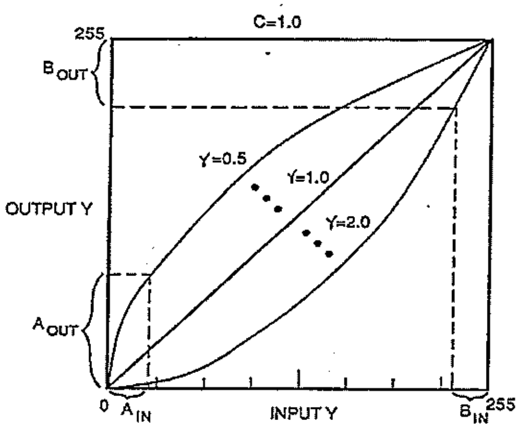

Figure 2 shows three curves, each representing a particular transfer function, each selected based on the location of a particular pixel and the resulting average value of the pixels surrounding that pixel. When the average of the surrounding pixels is at the mid-point, $\gamma = 1.0$, and the individual pixel is not transformed.

When the area average increases above the midpoint ("high scene light intensity levels"), the curve will gradually shift in the direction of the curve $\gamma = 2.0$. The patent specification defines "highest value" as the maximum value in the dynamic range, which in Figure 2 would be 255. ('381 Pat., 4:66). And the patented system would provide "increased contrast" between a pixel with the "highest light intensity level" and surrounding pixels by leaving the highest value at the same level, while dropping the values of the surrounding pixels.

The highest value, 255, would not change, because the transform function is $Y_{OUT} = Y_{MAX} * (Y_{IN}/Y_{MAX})^{\gamma}$. (*Id.,* 4:64). When $Y_{IN} = 255$, Y_{IN}/Y_{MAX} must equal 1 (because 255/255 = 1). Therefore, for every value of γ, $(1)^{\gamma}$ must also equal 1. And $Y_{MAX} * 1 = Y_{MAX}$, which therefore becomes Y_{OUT}. In other words, Y_{OUT} must stay at 255 when Y_{IN} is 255.

The surrounding values that are not 255, however, would be reduced by the transfer function to increase their difference with the "highest value," 255, and thereby increasing contrast. This alteration is shown by comparing B_{IN} and B_{OUT} in Figure 2 above. As these values get farther from 255, the more the pixel at 255 will stand out, providing "higher contrast."

The transform function works the same way for the lowest pixel value, 0, which corresponds to low light. As the area average falls below the midpoint ("low scene light intensity levels"), the curve will gradually shift in the direction of $\gamma = 0.5$. (*Id.*, 5:48–50). In this case, a pixel with a value of 0 will remain the same, but contrast will increase because the values of the surrounding pixels will be boosted. If $Y_{IN} = 0$, then Y_{OUT} will always equal 0:

$$Y_{OUT} = Y_{MAX} * (0/Y_{MAX})^{\gamma}$$

The surrounding pixels will be increased according to the curve in Figure 2 where $\gamma = 0.5$. This alteration is shown by comparing A_{IN} and A_{OUT} in Figure 2 above.

Simply stated, high average values are those above the mid-point and low average values are those below the mid-point. The "highest value" is 255, and the "lowest" is 0. These terms are not indefinite.

IV. CONCLUSION

HP's constructions, and its arguments in support, suffer from numerous flaws. They lack intrinsic support, rely improperly on inventor testimony, and seek to limit the invention to the preferred embodiment, often at the same time. The collected intrinsic evidence, however, supports Polaroid's constructions, and the Court should adopt them for that reason.

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January 25, 2008

CERTIFICATE OF SERVICE

I, the undersigned, hereby certify that on January 30, 2008, I electronically filed the foregoing with the Clerk of the Court using CM/ECF, which will send notification of such filing(s) to the following:

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EXHIBIT A

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EXHIBIT B

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remaining chapters deal with the theory of digitization (4); coding and compression (5); enhancement (6); restoration and estimation (7); reconstruction from projections (8); registration and matching (9); segmentation into parts (10); representation of parts and geometric property measurement (11); and nongeometric properties, picture descriptions, and models for classes of pictures (12).

The level of treatment emphasizes concepts, algorithms, and (when necessary) the underlying theory. We do not cover hardware devices for picture input (scanners), processing, or output (displays); nondigital (e.g., optical) processing; or picture processing software.

SCENES, IMAGES, AND DIGITAL PICTURES

Scenes and Images

When a scene is viewed from a given point, the light received by the observer varies in brightness and color as a function of direction. Thus the information received from the scene can be expressed as a function of two variables, i.e., of two angular coordinates that determine a direction. (The scene brightness and color themselves are resultants of the illumination, reflectivity, and geometry of the scene; see Section 6.2.2.)

In an optical image of the scene, say produced by a lens, light rays from each scene point in the field of view are collected by the lens and brought together at the corresponding point of the image. Scene points at different distances from the lens give rise to image points at different distances; the basic equation is

$$\frac{1}{u} + \frac{1}{v} = \frac{1}{f}$$

where u, v are the distances of the object and image points from the lens (on opposite sides), and f is a constant called the focal length of the lens. If u is large, i.e., the scene points are all relatively far from the lens, $1/u$ is negligible, and we have $v \approx f$, so that the image points all lie at approximately the same distance from the lens, near its "focal plane." Thus the imaging process converts the scene information into an illumination pattern in the image plane; this is still a function of two variables, but they are now coordinates in the plane. (Image formation by optical systems will not be further discussed here. On the geometry of the mapping from three-dimensional scene coordinates to two-dimensional image coordinates, see Section 9.1.2.)

We can now record or measure the pattern of light from the scene by placing some type of sensor in the image plane. (Some commonly used

sensors will be mentioned in the next paragraph.) Any given sensor has a characteristic spectral sensitivity, i.e., its response varies with the color of the light; thus its total response to the light at a given point can be expressed by an integral of the form $\int S(\lambda)I(\lambda)\,d\lambda$, where $I(\lambda)$ is light intensity and $S(\lambda)$ is sensitivity as functions of wavelength. This means that if we use only a single sensor, we can only measure (weighted) light intensity. If we want to measure color, we must use several sensors having different spectral responses; or we must split the light into a set of spectral bands, using color filters, and measure the light intensity in each band. (Knowing the intensities in three suitably chosen bands, e.g., in the red, green, and blue regions of the spectrum, is enough to characterize any color; see Section 3.3.) In other words, when we use only one sensor, we are representing the scene information by a scalar-valued function of position in the image, representing scene brightness. To represent color, we use a k-tuple (usually a triple) of such functions, or equivalently, a vector-valued function, representing the brightnesses in a set of spectral bands. We will usually assume in this book that we are dealing with a single scalar-valued brightness function. Photometric concepts and terminology will not be further discussed here; we use terms such as "brightness" and "intensity" in an informal sense.

Image sensors will not be discussed in detail in this book, but we briefly mention here some of the most common types.

(a) We can put an *array* of photosensitive devices in the image plane; each of them measures the scene brightness at a particular point (or rather, the total scene brightness in a small patch).

(b) We need only a single photosensor in the image plane if we can illuminate the scene one point (or small patch) at a time; this is the principle of the *flying-spot scanner*. Similarly, we need only one photosensor if we can view the scene through a moving aperture so that, at any given time, the light from only one point of the scene can reach the sensor.‡

(c) In a *TV camera*, the pattern of brightnesses in the scene is converted into an electrical charge pattern on a grid; this pattern can then be scanned by an electron beam, yielding a *video signal* whose value at any given time corresponds to the brightness at a given image point.

In all of these schemes, the image brightness is converted into a pattern of electrical signals, or into a time-varying signal corresponding to a sequential scan of the image or scene. Thus the sensor provides an electrical or electronic analog of the scene brightness function, which is proportional to it,

‡ As a compromise between (a) and (b), we can use a one-dimensional array of sensors in the image plane, say in the horizontal direction, and scan in the vertical direction, so that light from only one "row" of the scene reaches the sensors at any given time.

if the sensors are linear. More precisely, an array sensor provides a discrete array of samples of this function; while scanning sensors provide a set of cross sections-of-the-function along the lines of the scanning pattern.

If, instead of using a sensor, we put a piece of photographic film (or some other light-sensitive recording medium) in the image plane, the brightness pattern gives rise to a pattern of variations in the optical properties of the film. (Color film is composed of layers having different spectral sensitivities; we will discuss here only the black-and-white case.) In a film transparency, the optical transmittance t (i.e., the fraction of the light transmitted by the film) varies from point to point; in an opaque print, the reflectance r (= the fraction of light reflected) varies. Evidently we have $0 \leqslant t \leqslant 1$ and $0 \leqslant r \leqslant 1$. The quantity $-\log t$ or $-\log r$ is called optical *density*; thus a density close to zero corresponds to almost perfect transmission or reflection, while a very high density, say 3 or 4, corresponds to almost perfect opaqueness or dullness (i.e., only 10^{-3} or 10^{-4} of the incident light is transmitted or reflected). For ordinary photographic processes, the density is roughly a linear function of the log of the amount of incident light (the log of the "exposure") over a range of exposures; the slope of this line is called photographic *gamma*. Photographic processes will not be discussed further in this book. A photograph of a scene can be converted into signal form by optically imaging it onto a sensor.

Pictures and Digital Pictures

We saw in the preceding paragraphs that the light received from a scene by an optical system produces a two-dimensional image. This image can be directly converted into electrical signal form by a sensor, or it can be recorded photographically as a picture and subsequently converted. Mathematically, a *picture* is defined by a function $f(x, y)$ of two variables (coordinates in the image plane, corresponding to spatial directions). The function values are brightnesses, or k-tuples of brightness values in several spectral bands. In the black-and-white case, the values will be called *gray levels*. These values are real, nonnegative (brightness cannot be negative), and bounded (brightness cannot be arbitrarily great). They are zero outside a finite region, since an optical system has a bounded field of view, so that the image is of finite size; without loss of generality, we can assume that this region is rectangular. Whenever necessary, we will assume that picture functions are analytically well-behaved, e.g., that they are integrable, have invertible Fourier transforms, etc.

When a picture is digitized (see Chapter 4), a *sampling* process is used to extract from the picture a discrete set of real numbers. These *samples* are

usually the gray levels at a regularly spaced array of points, or, more realistically, average gray levels taken over small neighborhoods of such points. (On other methods of sampling see Section 4.1.) The array is almost always taken to be Cartesian or rectangular, i.e., it is a set of points of the form (md, nd), where m and n are integers and d is some unit distance. (Other types of regular arrays, e.g., hexagonal or triangular, could also be used; see Section 11.1.7, Exercise 4, on a method of defining a hexagonal array by regarding alternate rows of a rectangular array as shifted $d/2$ to the right.) Thus the samples can be regarded as having integer coordinates, e.g., $0 \leqslant m < M, 0 \leqslant n < N$.

The picture samples are usually *quantized* to a set of gray level values which are often taken to be equally spaced (but see Section 4.3). In other words, the *gray scale* is divided into equal intervals, say $I_0, \ldots, I_K$, and the gray level $f(x, y)$ of each sample is changed into the level of the midpoint of the interval I_i in which $f(x, y)$ falls. The resulting quantized gray levels can be represented by their interval numbers $0, \ldots, K$, i.e., they can be regarded as integers.

The result of sampling and quantizing is a *digital picture*. As just seen, we can assume that a digital picture is a rectangular array of integer values. An element of a digital picture is called a *picture element* (often abbreviated *pixel* or *pel*); we shall usually just call it a *point*. The value of a pixel will still be called its gray level. If there are just two values, e.g., "black" and "white," we will usually represent them by 0 and 1; such pictures are called two-valued or binary-valued.

Digital pictures are often very large. For example, suppose we want to sample and quantize an ordinary (500-line) television picture finely enough so that it can be redisplayed without noticeable degradation. Then we must use an array of about 500 by 500 samples, and we should quantize each sample to about 50 discrete gray levels, i.e., to about a 6-bit number. This gives us an array of 250,000 6-bit numbers, for a total of $1\frac{1}{2}$ million bits. In many cases, even finer sampling is necessary; and it has become standard to use 8-bit quantization, i.e., 256 gray levels.

Except on the borders of the array, any point (x, y) of a digital picture has four horizontal and vertical neighbors and four diagonal neighbors, i.e.,

$$\begin{array}{ccc} (x-1, y+1) & (x, y+1) & (x+1, y+1) \\ (x-1, y) & (x, y) & (x+1, y) \\ (x-1, y-1) & (x, y-1) & (x+1, y-1) \end{array}$$

In this illustration of the 3×3 *neighborhood* of a point we have used Cartesian coordinates (x, y) with x increasing to the right and y increasing upward. There are other possibilities; for example, one could use matrix coordinates (m, n), in which m increases downward and n to the right. Note

that the diagonal neighbors are $\sqrt{2}$ units away from (x, y), while the horizontal and vertical neighbors are only one unit away. If we think of a pixel as a unit square, the horizontal and vertical neighbors of (x, y) share a side with (x, y), while its diagonal neighbors only touch it at a corner. Some of the complications introduced by the existence of these two types of neighbors will be discussed in Chapter 11. Neighborhoods larger than 3×3 are sometimes used; in this case, a point may have many types of neighbors.

If (x, y) is on the picture border, i.e., $x = 0$ or $M - 1$, $y = 0$ or $N - 1$, some of its neighbors do not exist, or rather are not in the picture. When we perform operations on the picture, the new value of (x, y) often depends on the old values of (x, y) and its neighbors. To handle cases where (x, y) is on the border, we have several possible approaches:

(a) We might give the operation a complex definition that covers these special cases. However, this may not be easy, and in any case it is computationally costly.

(b) We can regard the picture as cyclically closed, i.e., assume that column $M - 1$ is adjacent to column 0 and row $N - 1$ to row 0; in other words, we take the coordinates (x, y) modulo (M, N). This is equivalent to regarding the picture as an infinite periodic array with an $M \times N$ period. We will sometimes use this approach, but it is usually not natural, since the opposite rows and columns represent parts of the scene that are not close together.

(c) We can assume that all values outside the picture are zero. This is a realistic way of representing the image (see the first paragraph of this section), but not the scene.

(d) The simplest approach is to apply the operation only to a *subpicture*, chosen so that for all (x, y) in the subpicture, the required neighbors exist in the picture. This yields results all of which are meaningful; but note that the output picture produced by the operation is smaller than the input picture.

Operations on Pictures

In this book we shall study many different types of operations that can be performed on digital pictures to produce new pictures. The following are some of the important types of picture operations:

(a) *Point operations*: The output gray level at a point depends only on the input gray level at the same point. Such operations are extensively used for gray scale manipulations (Section 6.2) and for segmentation by pixel classification (Section 10.1). There may be more than one input picture; for example, we may want to take the difference or product of two pictures, point by point. In this case, the output level at a point depends only on the set of input levels at the same point.

(b) *Local operations*: The output level at a point depends only on the input levels in a neighborhood of that point. Such operations are used for deblurring (Section 6.3), noise cleaning (Section 6.4), and edge and local feature detection (Sections 10.2 and 10.3), among other applications.

(c) *Geometric operations*: The output level at a point depends only on the input levels at some other point, defined by a geometrical transformation (e.g., translation, rotation, scale change, etc.), or in a neighborhood of that point. On such operations see Section 9.3.

An operation $\mathcal{O}$ is called *linear* if we get the same output whether we apply $\mathcal{O}$ to a linear combination of pictures (i.e., we take $\mathcal{O}(af + bg)$) or we apply $\mathcal{O}$ to each of the pictures and then form the same linear combination of the results (i.e., $a\mathcal{O}(f) + b\mathcal{O}(g)$). Linear operations on pictures will be discussed further in Section 2.1.1. Point and local operations may or may not be linear. For example, simple stretching of the gray scale ($\mathcal{O}(f) = cf$) is linear, but thresholding ($\mathcal{O}(f) = 1$ if $f \geqslant t$, $= 0$ otherwise) is not; local averaging is linear, but local absolute differencing is not. Geometric operations are linear, if we ignore the need to redigitize the picture after they are performed (Section 9.3).

$\mathcal{O}$ is called *shift invariant* if we get the same output whether we apply $\mathcal{O}$ to a picture and then shift the result, or first shift the picture and then apply $\mathcal{O}$. Such operations will be discussed further in Section 2.1.2. The examples of point and local operations given in the preceding paragraph are all shift invariant, but we can also define shift-variant operations of these types, e.g., modifying the gray level of a point differently, or taking a different weighted average, as a function of position in the picture. The only shift-invariant geometric operations are the shifts, i.e., the translations. It is shown in Section 2.1.2 that an operation is linear and shift invariant iff it is a *convolution*; this is an operation in which the output gray level at a point is a linear combination of the input gray levels, with coefficients that depend only on their positions relative to the given point, but not on their absolute positions.

In Chapters 11 and 12 we will discuss *picture properties*, i.e., operations that can be performed on pictures to produce numerical values. In particular, we will deal with *point* and *local properties* (whose values depend only on one point, or on a small part, of the picture); *geometric properties* of picture subsets (whose values depend only on the set of points belonging to the given subset, but not on their gray levels); and *linear properties* (which give the same value whether we apply them to a linear combination of pictures, or apply them to each picture and then form the same linear combination of the

results). It will be shown in Section 12.1.1a that a property is linear and bounded (in a certain sense) iff it is a linear combination of the picture's gray levels.

We will also be interested in certain types of *transforms* of pictures, particularly in their *Fourier transforms*. These are of interest because they make it easier to measure certain types of picture properties, or to perform certain types of operations on pictures, as we will see throughout this book. Basic concepts about (continuous) Fourier transforms are reviewed in Sections 2.1.3 and 2.1.4, and various types of discrete transforms are discussed in Section 2.2.

A GUIDE TO THE LITERATURE

Papers on picture processing and its various applications are being published at a rate of more than a thousand a year. Regular meetings are held on many aspects of the subject, and there are many survey articles, paper collections, meeting proceedings, and journal special issues. Picture processing is also extensively represented in the literature on (two-dimensional) signal processing and pattern recognition (and, to a lesser extent, artificial intelligence).

No attempt has been made here to give a comprehensive bibliography. Selected references are given at the end of each chapter on the subject matter of that chapter, but their purpose is only to cite material that provides further details about the ideas treated in the chapter—it is not practical to cite references on every idea mentioned in the text. Annual bibliographies [9–19] covering some of the non-application-oriented U.S. literature contain several thousand additional references, arranged by subject; they may be consulted for further information.

The principal textbooks on the subject through 1979, including the predecessors to this book, are [1–8, 20]. The following are some of the journals that frequently publish papers on the subject:

IEEE Transactions on Acoustics, Speech and Signal Processing
IEEE Transactions on Communications
IEEE Transactions on Computers
IEEE Transactions on Information Theory
IEEE Transactions on Pattern Analysis and Machine Intelligence
IEEE Transactions on Systems, Man, and Cybernetics
Computer Graphics and Image Processing
Pattern Recognition

We shall not attempt to list the numerous meeting proceedings or paper collections here; see [9–19] for further information.

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COMMENT:

F A X C O V E R

Date:	1/24/2008
Send to:	Michelle Skinner
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☐ URGENT ☐ REPLY ASAP ☐ PLEASE COMMENT ☐ PLEASE REVIEW ☐ FOR YOUR INFORMATION

TOTAL PAGES, INCLUDING COVER: 7

Comments:

Michelle,

I am attaching a copy of the first chapter of a famous textbook from the '80s. It is a very well known book that all of us who went through Digital Image Processing courses in the late '80s had to have, at least as reference. Please take a look and let me know if this covers what you are looking for. I underlined some relevant passages. Please let me know if you have questions or need any additional information.

Regards,

Peggy

Dr. Peggy Agouris
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